Investigating an Underwater Habitat by Submersible

NATIONAL MARINE SANCTUARIES ™

Investigating a Submerged Habitat by Submersible

Introduction

Many marine habitats are not easy to access. Habitats that are deep and offshore require unique methods and technologies to learn about what lives there. Luckily, in this day of age, technology offers options to learn about them.

Guiding Question

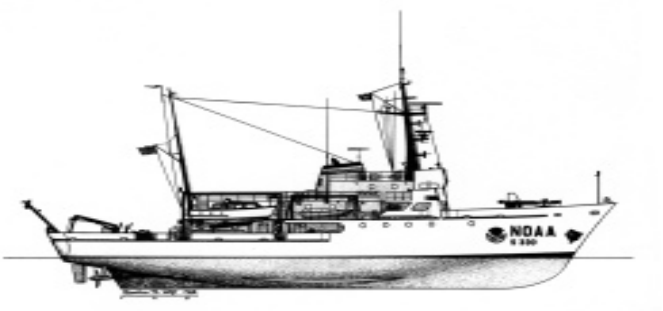
How do you characterize and monitor an offshore and underwater environment not accessible by SCUBA?

California Standards

Grades Nine-Twelve
Ecology
6b-Students know how to analyze changes in an ecosystem resulting from changes in climate, human activity, introduction of nonnative species, or changes in population size.

Investigation and Experimentation
a-Select and use appropriate tools and technology (such as computer-linked probes, spreadsheets, and graphing calculators) to perform tests, collect data, analyze relationships, and display data
b-Identify and communicate sources of unavoidable experimental error
c-Identify possible reasons for inconsistent results, such as sources of error or uncontrolled conditions
d-Formulate explanations by using logic and evidence

Grade 8
Investigation and Experimentation
Construct appropriate graphs from data and develop quantitative statements about the relationships between variables.



Description of Activity

In this activity, students will work in groups and compare different habitats of Cordell Bank using video taken from a research submersible. Students will be trained on species identification and estimating abundance. Students will view submersible footage and do a habitat characterization exercise for two different habitats in Cordell Bank National Marine Sanctuary

Technical Requirements

Training module is in a powerpoint slideshow created on a Macintosh. The included CD has both html format and the original slideshow. The ID guide (PDF format) that accompanies the training module is able to be reproduced off the CD. The video footage is available on VHS tape and DVD.

Time Commitment

1-2 class periods
Day 1- introduce background material, training slide show, and practice video
Day 2-Review species again, view rocky reef and soft bottom video transects, analyze data, answer questions

Materials

Additional Materials needed

Video footage of rocky reef and soft bottom habitats at Cordell Bank : practice video includes footage of launch and retrieval of submersible.
ID guides
graph paper
watch clock, or timer

Prior to activity

1. Make multiple copies of data sheet for students (each student gets 3 copies for: practice, rocky reef, and soft bottom transects)

Directions for Activity

1. Introduce students to background information: students should be able to identify the difference between habitat characterization and monitoring and the different methods for investigating underwater habitats.

2. Break students up into groups of 4 students each. Each group will get an ID guide to refer to during species training and while they are recording data during each transect.

3. Hand out 3 data sheets to students. Each student should fill in the blank next to habitat on each page practice, rocky reef, soft bottom

4. To prepare students to be familiar with data sheet, go over what each row and column is for.

*Next to each species there are 4 boxes: the first 3 are for the video transect, broken tally how many of "their" species they see during each minute. Under each species listed, there is a row that says Total Abundance. After the transect is complete, each student will tally up how many they counted and assign an abundance rating (**single, few, many, abundant**) for each minute. The Notes section is to describe anything they find particularly interesting about the environment, or a species not on the species list.*

5. Assign species
Each student will only be looking for 1 or 2 species. Some species may be abundant in one habitat and completely absent in the other.

6. Introduce students to species and habitat types with powerpoint slide show. The slide show has a script to point out special identifying features of species and life history facts and how to estimate abundance.
*You may want to prepare them further by having each student research information about species prior to slide show. See Encyclopedia of the Sanctuary at www. marinelife.noaa. gov

Measuring Abundance
During the transect, students will mark down with a tally mark how many times they see a particular species, or continuosly count and record. This can be difficult depending on the species, and it is for the experts that review the tapes as well. Try to count or estimate the best you can. The transect will be broken up into 3 one minute segments. The teacher **(YOU!)** will be watching the time and call out after each one minute segment is complete. After the transect is complete each student should count how many they recorded for their species and assign an abundance category for each minute segment.

Single-one solitary individual
Few-2-10 individuals
Many-10-100 individuals
Abundant-greater than 100 individuals

** Those counting fish will have a difficult time with large schools of fish. If they can't count them, have them estimate if its between 10-100 or greater than 100 and just write Many or Abudant instead of trying to count.*

8. After reviewing slide show, there is a 1 minute practice video. The students will get used to watching underwater footage at the speed of the submersible. Have students look for the species they are responsible for and fill out the practice data sheet. ** the video shows deployment of the submersible and starts with rocky reef footage, then goes to the soft bottom habitat. Have students refer to ID guide to help them remember what their species looks like.*

9. Play practice video and have students record data. Debrief exercise with students, what was hard; what do they need to do differently next time. They may discover they need to go over the video a few times to see well.

10. Get ready for 3 minute rocky reef transect; students use the rocky reef data sheet. After transect, have students tally up how many they counted and assign an abundance category below each minute category. ** note: rocky reef video footage is pretty dense with life, you may want to rewind and play a few times*

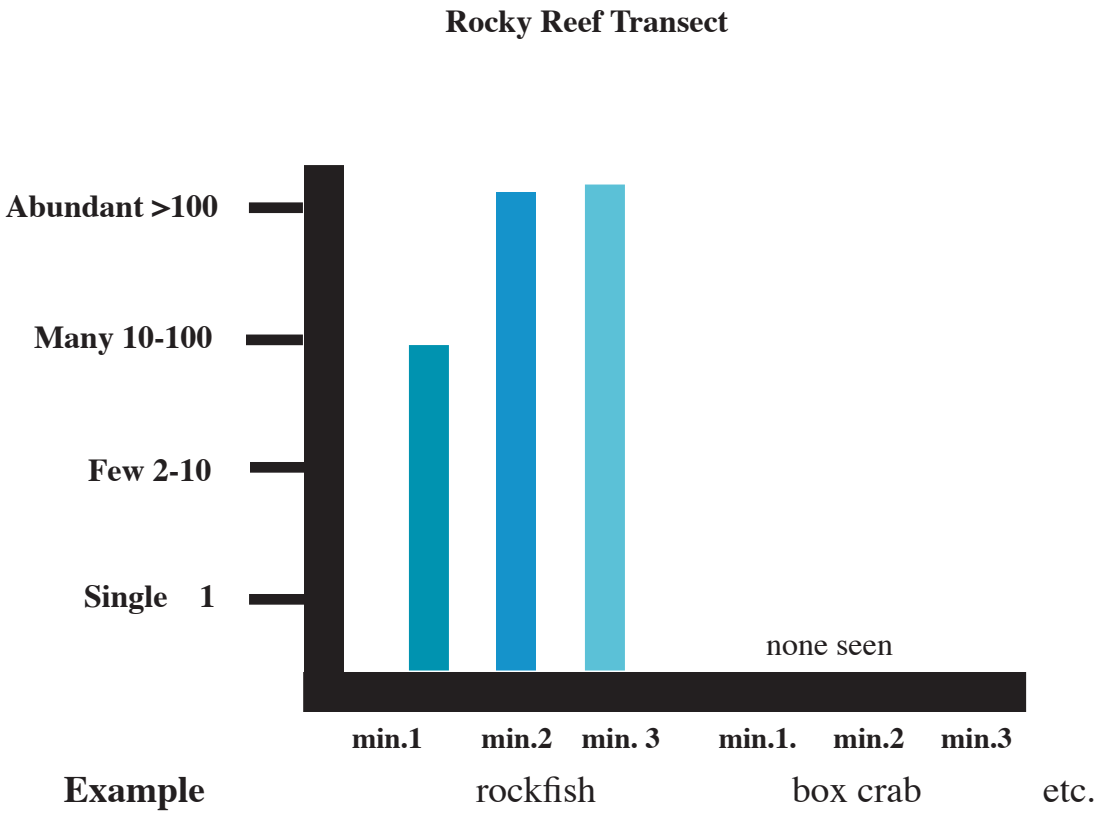
11. After students have recorded the abundance codes for each minute on the rocky reef transect, play the 3 minute soft bottom transect, and immediately following fill out the abundance categories for the soft bottom transect.

12. After the class has completed both rocky reef and soft bottom transects, have students share their data amongst their group so that they have abundance codes for each species on the data sheet. Each student should have a complete data sheet for both rocky and soft bottom transects.

Compare amongst the groups the abundance categories for each species. Was each group consistent? Why or why not?

Analyze the data

Have students create a graph for each of the habitats and all the species to visualize the data or do this as group at front of classroom on black/white board.



List each species along x-axis and each minutes abundance

*** Have students graph each minute in a different color along the x-axis.**

Questions to go with graphing exercise

1. Compare and contrast the two habitats you observed on the transect.

2. What species were most abundant in the rocky habitat? soft habitat? Why do you think?

3. What organisms were most abundant throughout all three minutes of both transects?

4. Minute to minute did the abundance for each species vary? Did the habitat vary minute to minute? Describe what you saw in a few sentences.

5. Based on the two video transects and the graphs you created, what species are most abundant in Cordell Bank National Marine Sanctuary?

6. What variables exist in doing a study like this?

7. If you were a Sanctuary manager, what maritime activities would you be concerned about?

Exploring remote environments

How do scientists explore and study underwater habitats offshore that cannot be visited using SCUBA? Marine technology has considerably improved in the 21st century, allowing scientists to go deeper and further than ever before. There are numerous marine environments that are being explored for the first time with this technology. In Cordell Bank National Marine Sanctuary, underwater technology allows us to safely monitor and observe the main feature of the Sanctuary, Cordell Bank.

Scientists are able to conduct habitat characterization studies on the Bank using remotely operated vehicles **(ROV)**s and **research submersibles**. Both of these technologies are expensive and each has benefits and drawbacks. A ROV is a vehicle with cameras and sensors that is motorized and operated by someone on the surface. It is attached to the boat by a long cable (tether). Using monitors and data delivered by the sensors, the operators can see where they are driving the vehicle. The only area the operators see is what the camera sees, and delivers to screens on the ship. Some limitations to using an ROV include: the distance traveled is limited by the length of the tether, the underwater currents, and not being able to see too far ahead while driving the vehicle.

An ROV being deployed from a ship
photo: CBNMS

2-person submersible being deployed
photo: CBNMS

A research submersible is an independent vessel that is deployed from a ship and is operated by a pilot in the submersible itself. It too has sensors and instruments that collect information while at depth.

Submersibles vary in how many passengers they can carry, how deep they can go, and how long they can stay down. One of the most important differences is that submersibles are manned and are untethered.

What is monitoring and habitat characterization?

The first stage in monitoring any habitat is identifying the physical and biological resources that are present. You have to know what it is there before you can determine if it has changed over time. Mapping and conducting a species inventory can accomplish this first step. This is the site characterization phase of a monitoring project. **Monitoring** is tracking the changes in a habitat over a long period of time.

Habitat Characterization

In order to understand any natural environment and make wise decisions that lead to its protection, sanctuary managers need several critical pieces of information.

These include:
1. Identifying what is there (the "parts" of an ecosystem such as the algae, plants, animals, water temperature, currents, water quality etc.)
2. The ecosystem's condition in the past (if possible)

Habitat (site) characterizations are detailed reports that contain information on the biological and physical environment, cultural history, and human-use patterns. They chronicle the history of discovery and use, the record of scientific investigations, the pressures being placed on natural and cultural resources, and the nature of attempts to protect the resources. Properly done, they are complete sources of current information for an area of interest.

Site characterizations can provide managers with information that helps them make effective decisions when it comes to managing human activities in protected areas, setting agendas for research, monitoring, education, outreach, and enforcement programs; and using the most appropriate methods to restore an area.

Transects

When conducting site characterizations, there are a number of ways scientists document the presence and abundance of species relative to the environment's physical factors. One method is conducting vertical and horizontal transects.

Vertical transects in the ocean are useful to profile the ocean's physical and biological layering. Imagine dropping a line from one point in the water column down to another. Physical factors are observed and recorded at various points along this line, or transect. Increments along the transect are usually evenly spaced, and when combined with similar transects they describe/define the environment and may reveal changes taking place due to water depth, temperature or other phenomena.

Horizontal transects are conducted in a similar way. These are most often used along the seafloor or at a particular depth. For instance, a horizontal transect at a depth of 600 meters might look for distribution of fish along this depth. A horizontal transect conducted from a submersible can have several different protocols.
Protocols to identify when conducting a horizontal transect are:

o The rate of speed of the submersible
o Field of vision that you will count species in
o How to measure abundance
o How to remain consistent among observers

These techniques provide researchers with methods to construct models of an ecosystem while only studying small portions of it. The models help us understand how an ecosystem functions. They may describe the flow of energy through a system or they may allow us to predict the effects of natural or human-caused events in an ecosystem.

Diving is only the first part!

Whether the method of investigation is a ROV or submersible, collecting video footage and other data is only the first stage in the process of characterizing the habitat. Experts then review the videotapes over and over again. They identify the habitat and how frequently it changes during the transect, identify the species size, and abundance, and identify how the species are using the habitat. Then all the data is compiled and analyzed in graphs and charts to understand it.

Watching the monitors

ROV pilots

photos: CBNMS

Vocabulary List

Monitoring	tracking changes in an environment over time
Habitat (site) characterization	mapping and identifying physical and biological conditions present at one time
Horizontal transect	a measurement along a consistent depth contour that documents the presence of species
Vertical transect	a measurement along a line from top to bottom with known intervals, measuring physical and or biological conditions
ROV	Remotely Operated Vehicle- a large machine that is equipped with sensors, cameras, motors used to investigate habitats below the surface of the ocean and is attached to the topside vessel with a tether
Submersible	an independent vessel that is launched from a topside vessel equipped with sensors, cameras, and is driven by a pilot. Depending on the size, passenger/passengers observe the habitat live from the vessel.

National Marine Sanctuaries

Questions on Habitat Characterization

1. Why do you think it is important to monitor a marine habitat?

2. What is the difference between habitat characterization and monitoring?

3. When faced with the choice of using an ROV or submersible to explore a habitat, what are some advantages or drawbacks to using either technology?

4. If designing a study around a habitat you know nothing about, what pieces of information would help you to best set up a study?

5. Based on what you observed on your transect, what further questions would you want to address in a monitoring program?

6. What was challenging about completing the transects using the submersible footage?

Student Name: _____ ***Data sheet: Habitat*** _____

Species	0-1 minute	1-2 minutes	2-3 minutes	Total Abundance
Box Crab				
Sea Cucumber				
Rockfish				
Ratfish				

(S) Single 1
(F) Few 2-10
(M) Many 10-500
(A) Abundant 500+

Training Module

This script accompanies the training slide show to familiarize students with the species they will be identifying and counting while viewing the rocky reef and soft bottom video segments. Students should take notes about identifying characteristics.

1. Opening Slide (NMS Logo)	*Today we are going to to look at an underwater habitat in one of our National Marine Sanctuaries. National Marine Sanctuaries are sort of like America's National Parks, except they are in the water. These marine protected areas balance long term conservation with compatible uses. Scientists conduct research in the sanctuaries, so managers can make smart decisions about potential impacts or use of these areas. Today, we are going to look at the underwater habitats of Cordell Bank National Marine Sanctuary in California.*
2. Habitat Characterization (photo: Cordell Expeditions)	*When scientists are learning about a habitat they attempt to describe what species are present, what the habitat is like, and how abundant species may be. Many observers have studied these species for years and are experts in a particular category of animals i.e.: rockfish experts, invertebrate experts. Today you will get acquainted with a few species that are commonly seen in the rocky reef and soft bottom offshore habitats of Cordell Bank National Marine Sanctuary. You will become familiar with identifying characteristics for each species, and learn how to estimate their abundance.*
3. Habitats- Rocky Reef (photos: Kip Evans)	*Habitat that is hard in nature is known as rocky reef. Some of these rocky areas look like boulders, some areas are full of cobble like material, and the higher reaches of the Bank are jagged and rough. This habitat provides a place for invertebrates to live. It also provides vital fish habitat. Who knew there were colorful reefs in California?*
4. Habitats- Soft Bottom (Photo: CBNMS)	*The soft bottom habitat varies from sandy to muddy. The sandy areas are made up of carbonate material (broken up shells and corals) and/or mud. One of the goals of characterizing the benthic/bottom habitats in Cordell Bank National Marine Sanctuary is to see how species use the soft bottom vs. the rocky reef areas and what species are present in each.*
5. Species Identification (photos: Cordell Expeditions)	*What do you look for when identifying organisms? Characteristics that you should pay attention to are the body shape, the color, its behavior, and the habitat you are reviewing. Some species may be masters of camouflage on the soft bottom, but stick out in the rocky reef areas.*
6. Sea Cucumber (photo:CBNMS)	*Sea Cucumbers are filter-feeding invertebrates seen in both habitats of the Bank. They only come in one shape, but sometimes are stretched out long and bent in shape. Keep your eyes open on the rocky boulders in the distance for that long "hot dog" shape. They typically are seen individually.*

7. Box Crab (photo:CBNMS)	*Box Crabs are typically only over the soft bottom, scavenging for food in the soft sediments. They are slow moving and sometimes covered with a little mud, like in this picture.*
8. Rockfish (photo: Kip Evans)	*Rockfish are one of the most abundant and diverse species on Cordell Bank, coming in many colors and sizes. The body shape is distinctive. They have a football shaped body, spiny dorsal spines and big eyes and big lips! You may see them over rocky reef and soft bottom habitats in varying size and abundance.*
9. Juvenile rockfish (photo: Kip Evans)	*When rockfish are in their juvenile stage they can be seen in massive schools like this. This picture has many more than 500, putting them into the abundant category.*
10. Ratfish (photo: CBNMS)	*Ratfish are typically a deep-water species, and are completely cartilaginous like sharks are. There are a few ways to identify this fish. They are silvery and use their pectoral fins (on their sides) to maneuver around the habitat. They also have a flattish and pointed nose. In the video footage you may see their pectoral fins cast a distinctive shadow on the bottom.*
11. Abundance (photos: CBNMS, Kip Evans, Cordell Expeditions)	*During the video transect you will be watching for one species. After the transect is complete, you will assign an abundance category for the total amount counted during each minute of the transect. Single is for 1 individual by itself, Few is for 2-10 individuals, Many is for 10-500 and Abundant is for >500. Sometimes species are so abundant that they are hard to count. When species like the rockfish are seen in large schools (greater than 100 or 500) you can mark off "many" or "abundant" on your data sheet immediately.*
12. Abundance (photos: CBNMS)	*Look at each of these photos, you can see when its easier to count and when its not.*

13. Lasers (Photo: CBNMS)	*When viewing the video transect, you are going to notice two red dots that don't seem to go away. They are lasers set at a distance of 20 cm apart. These are set to get an accurate measurement of the species you are observing. This is particularly useful for studying rockfish, because it helps us to determine the age class of a fish.*
14. What is it? (Photo: CBNMS)	*Sometimes the video footage moves too fast to really see details of species, try to make out the overall shape and identifying features. Can you tell what this is? This is a rockfish, actually two. How can you tell?*
15. What is it? (Photo: CBNMS)	*You should be able to make out what this species is even though the picture is really blurry. (It's a cucumber)*
16. What is it? (Photo: CBNMS)	*Even in the dark, if you can make out the shapes of these animals. The top photos are a box crab, bottom left is a rockfish (see the spiky dorsal fin), and the bottom right is a ratfish.*
17. Characterizing Habitat: (photos: CBNMS and Kip Evans (rosy rockfish)	*Once we are able to identify the species in the habitats and how they are using them, we start to get a picture of what lives there. Once we gain this information we can then monitor year to year to track changes in the habitat over time.*
18. NMS logo	*Marine Protected Areas, like National Marine Sanctuaries are responsible for safeguarding these special areas for the future. Research provides information and data to best prepare for potential impacts. Potential impacts to a seafloor habitat could be cable laying, alternative energy like wave/wind generators, some types of fishing practices, observation equipment and more. Having more information about the habitats will help us to better protet them to function as they should in the marine ecosystem.*

Teacher Answer Sheet to Graphing Exercise Questions

1. Compare and Contrast the two habitats observed in the transect.

Rocky reef- very dense with invertebrate life, lots of fish, varied rocky terrain providing substrate for invertebrates to settle out on and refuge for groundfish such as rockfish. Soft bottom-less rocky terrain, less dense and less abundant with all species.

2. What species were most abundant in the rocky habitat? soft habitat? Why do you think?

The rocky reef provides substrate for invertebrates like sponge, hydrocoral, anemones, crabs, crinoids etc to hold onto which provides more habitat for fishes. The rocky reef substrate varies vertically in the abundance of invertebrates because up high in the water column there is more plankton and more sunlight, resulting in more food at these shallower depths for fishes. In the soft habitat, rockfish and ratfish were most abundant, besides the krill. Ratfish typicaly like deeper water which is near the base of the Bank where there is soft bottom habitat. The soft substrate also provides shelter for organisms that like to hide under the softer sediments, like sea pens, mollusks, crabs, and flatfishes.

3. What organisms were most abundant throughout all three minutes of both transects?
Rockfish were most abundant throughout the rocky reef transect and soft bottom transect, although their numbers of abundance varied quite a bit.

4. ***Minute to minute did the abundance for each species vary? Why do you think? Did the habitat vary minute to minute? Describe what you saw in a few sentences.***

For some species, the abundance did vary minute to minute in the same habitat. Some of the reef we passed was much closer in view than some of the more distant habitat, so we may have just not been able to see.

*5.****Based on the two video transects you viewed and the graphs you created, what species are most abundant in Cordell Bank National Marine Sanctuary?***

Rockfish are most abundant in both habitats although their abundance varied.

6. ***What variable exist in doing a study like this?*** Determining the field of view from the submersible to count varies. Generally in our transects we only count below the lasers. The distance away from the sub is calibrated on every dive, but must vary due to currents and obstructions in the path. Consistency amongst observers is a big variable. No doubt your students probably varied in how they counted and categorized the abundance categories. The speed of the sub. varies based on currents and interesting sightings. You probably noticed on the rocky transect that there were a few times when the sub slowed down or sped up. The flashes were from a camera mounted on the outside of the submersible.

7 . If you were a Sanctuary manager, what maritime activities would you be concerned about? Anything that causes disturbance to the bottom. The bottom is a living habitat supporting many species. The rocky reef habitat is fragile and certain fishing practices like trawling could damage it. Also, anchoring, or installation of telecommunication cables, or future alternative energy sources like wind/wave energy, could have a seafloor impact.

Teacher Answer Sheet to Habitat Characterization Questions

1. Why is it important to monitor marine habitats?
The only way to determine if a habitat has changed over time for natural reasons or human-caused reasons is to have documentation of what is there. Monitoring programs collect data that can be measured over time. We can evaluate the data over time and identify trends correlated with natural or un-natural events. Managers can use this information to better protect these areas with scientific information.

2. **What is the difference between habitat characterization and monitoring?**
Habitat Characterization identifies what is in the habitat being studied, it consists of a species inventory and a historical understanding of the ecosystem and its prior use and condition. You can consider it a "snapshot" picture. Monitoring is tracking changes in an environment over time. Note: the use of the word habitat and site can be used interchangeably when referring to characterization. Site refers to a specific place, while habitat is a more general term for the study.

3. **When faced with the choice of using an ROV or submersible to explore a habitat, what are some advantages or drawbacks to using either technology?**
Advantages to using a ROV include: 1. A ROV can go deeper and longer than a manned submersible, 2. It may be easier to manipulate a ROV closer to habitats at depth since it is smaller. 3. It is safer, if an accident happens underwater, at least nobody is hurt. **Disadvantages to using a ROV** include: 1. its hard to see very far ahead as the driver only sees what the camera sees, if you can't see very far ahead, it can be dangerous to the vehicle. 2. scientists only see what the screen sees as well. 3. since it is smaller, it can also be easily affected by strong currents. **Advantages to using a submersible include**: passengers get a larger perspective by being in the habitat itself, field of view around submersible is better than a ROV's field of view. **Disadvantages to using a submersible include:** limited amount of passengers, different submersibles are designed for different depths, but can only go so deep, there is an element of danger as technology can fail and human life could be at risk

4. If designing a study around a habitat you know nothing about, what pieces of information would help you to best set up a study?
Bathymetry maps showing the contours of the bottom would be helpful in that it gives you an idea of the depths in the area. The maps may reveal a varied terrain, where using a ROV could be risky. The tether could get caught up on rocks, pinnacles, and even sever and cause damage to the electronics. It would also be good to know the weather patterns and oceanography at various times of the year to best prepare for calm seas.

5**. Based on what you observed on your transect, what further questions would you want to address in a monitoring program?**
The Sanctuary is interested in monitoring the abundance and diversity of fishes over time. Although the Sanctuary does not manage fishing, closures enforced by the Pacific Fisheries Management Council have changed the use of Cordell Bank National Marine Sanctuary for an undetermined amount of time. By monitoring size of rockfish, abundance, and species diversity overtime, we may learn how this closure has affected the habitats and the species that live there.

6. **What was challenging about completing the transect using the submersible footage? answers based on opinion**

Extensions

Have students due a horizontal transect in their classroom, or at school, or at home.
Have students prepare their own data sheet for the area they will study.
Have students compare data from their transects.

Credits

video footage collected by Cordell Bank National Marine Sanctuary
(http://cordellbank.noaa.gov)
from Delta Submersible **(http://www.deltaoceanographics.com)**

Additional Resources

Channel Islands National Marine Sanctuary have online education activites that highlight monitoring in the marine environment. Plumes and Blooms specifically highlights research and monitoring conducted offshore.
http://www.channelislands.noaa.gov/edu/edu_act.html

Careers and Jobs in Marine Biology and Oceanography,
http://www.marine.stanford.edu/HMSweb/careers.html

The Marine Advanced Technology Education Center offers teacher workshops and curriculum that teach teachers how to build ROV's in their classroom.
http://www.marinetech.org/

The Bridge Ocean Science Teacher Resource Center has numerous marine science curriculum available online.
http:www.vims.edu/bridge/index.html

The Jason Project uses telepresence in bringing offshore habitats and far away places to schools and museums locally. The Jason Project is conducted in the National Marine Sanctuaries regularly.
http://www.jasonproject.org

Harbor Branch Oceanographic Institution
http://www.hboi.edu

Monterey Bay Aquarium Research Institute is a premier oceanographic research group. They often do live links from ROV dives in Monterey Canyon to the Monterey Bay Aquarium.
http://www.mbari.org

The NOAA Office of Ocean Exploration brings offshore expeditions to the web.
www.oceanexplorer.noaa.gov